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Activity, Reproduction, and Growth of *Opheodrys aestivus* in Illinois (Serpentes: Colubridae).

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The rough green snake, *Opheodrys aestivus* (Linnaeus), is widely distributed in the eastern United States (Conant, 1975), yet published life history data for it are scant. Although Tinkle (1960) presented observations on reproductive cycles in male and female *O. aestivus* in Lousiana, the remaining literature consists of scattered observations on oviposition and dates of hatching (Fitch, 1970). Other than a statement concerning a natural nest (Smith, 1961), no observations on reproduction by the species in Illinois have been published. During an examination of the female reproductive cycle in rough green snakes in Illinois, I also gathered data on activity and growth. These data are presented to help provide an understanding of the species' biology.

MATERIALS AND METHODS

Ninety-seven preserved specimens from throughout the species' range in Illinois were examined (Fig. 1). Additional data were taken from 6 living specimens from a single brood (see Reproduction). Preserved specimens are deposited in the Illinois Natural History Survey, Urbana, Illinois (INHS) and the Department of Zoology Research Museum, Southern Illinois University at Carbondale (SIUC) (Appendix 1).

Total and snout-vent lengths were measured to the nearest mm. Head length and eye length were measured to the nearest **0.1** mm with dial calipers. Twenty-five adult females were dissected and the numbers and sizes of ovarian follicles (greater than 1 mm diameter) and oviducal eggs were noted.

SEASONAL ACTIVITY

The period of activity, based on 70 specimens collected from 1884 to 1979, is from March to November. Adults are most active in April, May, July, September, and October (Table 1). The specimen collected in February (Table 1) was found dead, and probably was found hibernating by a predator (the head and neck of this specimen are badly chewed). It was found during a period of warm weather, however, and may have been active before it was killed.

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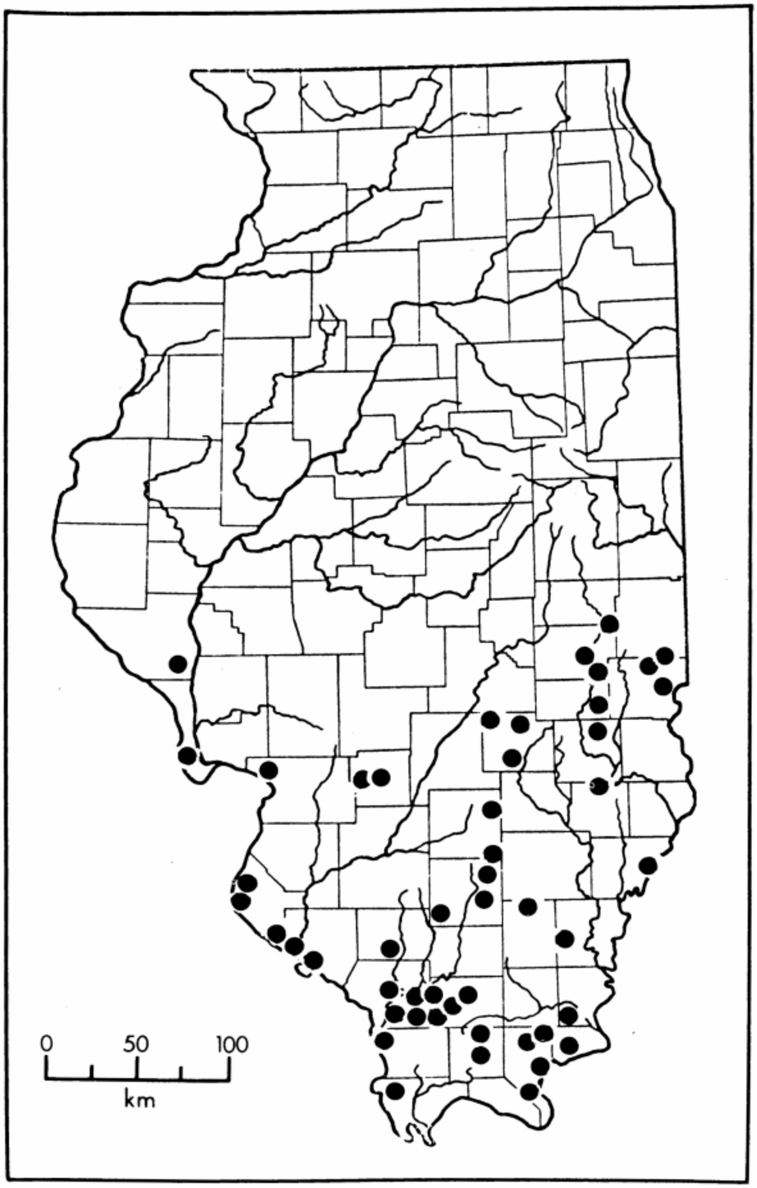

Figure 1. Map of Illinois showing localities (solid circles) for specimens of *Opheodrys aestivus* examined during this study.

Table 1. Frequency of collection of adult *Opheodrys aestivus* in Illinois, 1884 to 1979.

Month		No. Males	No. Females	Total	Sex Ratio (M:F)
February		0	1	1	—
March		1	0	1	—
April		6	4	10	1.5:1
May		7	8	15	1:1.1
June		1	3	4	1:3
July		2	8	10	1:4
August		2	4	6	1:2
September		10	3	13	3.3:1
October		4	5	9	1:1.3
November		0	1	1	—
	Total	33	37	70	1:1.1

Females appear to be more active than males in July and males more active than females in September (Table 1), but a X^2 test was not significant (« = 0.05), probably because of small sample sizes. If females are more active in July, the activity increase probably is a reflection of females seeking oviposition sites or searching for food to replenish energy reserves depleted during gestation. An increase in activity of adult males in September, if real, may be a result of an autumnal increase in sexual activity, a phenomenon documented for some other colubrids, e.g., *Thamnophis sirtalis* and *Carphophis amoenus* (Fitch, 1965; Clark, 1970). Male and female rough green snakes were present in equal numbers in all other months (Table 1).

The period of activity for Illinois *O. aestivus is* not appreciably different from that of rough green snakes in other localities (Wright and Wright, 1957). Barbour (1971) states that in Kentucky *O. aestivus* does not emerge from hibernation until late April or early May. This is usually true of Illinois snakes as well; most of the April records are for the last week of that month, and *O. aestivus is* rarely encountered in March (Table 1). In Louisiana, the snakes remain active into December (Tinkle, 1960). Peak abundance in Indiana occurs in September (Minton, 1972).

REPRODUCTION

Females with shelled oviducal eggs have been collected in late May, so copulation probably occurs in April or May, although it may take place in autumn (see Seasonal Activity). Smith (1950) cited an observation of copulation in May, apparently for snakes from Kansas.

Ovaries had four size classes of follicles (Class I, less than 1 mm diameter; II, 1-4 mm; III, 5-10 mm; IV, 12-21 mm). Follicles in each size class were derived from follicles in the next smaller size class, as in *Nerodia rhombifera* (Betz, 1963). Enlargement of Class II follicles (anestrous follicles—Dessauer and Fox, 1959; Aldridge, 1979) eventually to

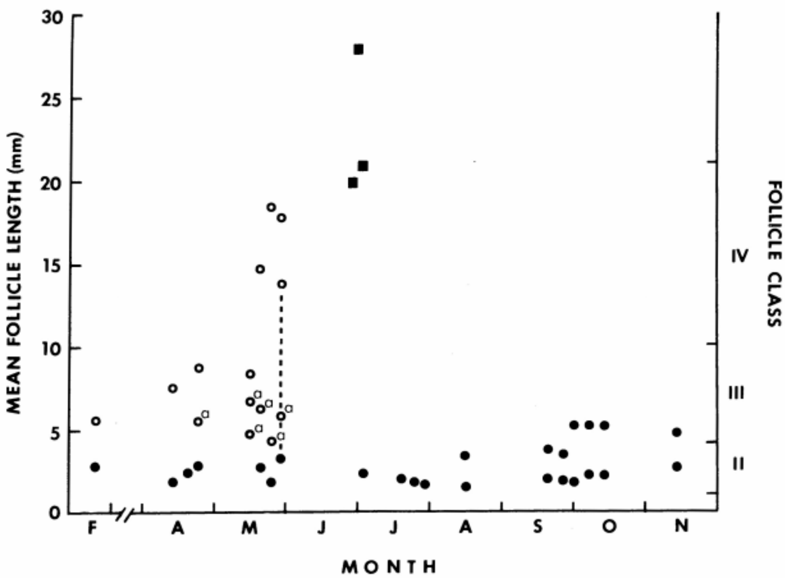

Figure 2. Mean lengths of ovarian follicles greater than 1 mm diameter and oviducal eggs in 22 *Opheodrys aestivus* from Illinois. Solid circles = anestrous follicles and late summer-fall (Class II) secondary vitellogenetic follicles, hollow circles = spring secondary vitellogenetic follicles, a = atretic follicles, and squares = oviducal eggs. When more than one female is shown for a given date, a broken line connects follicles in the same female. Mean ovarian follicle lengths for two of the gravid females are not plotted.

form Class IV follicles involves secondary vitellogenesis (Aldridge, 1979), which for *O. aestivus* in Illinois begins in August and continues through fall and spring, with follicles making the greatest and most rapid increase in size in spring (Fig. 2). Aldridge (1979) denoted the fall-spring vitellogenetic pattern as Type II Vitellogenesis. *Opheodrys aestivus* in Louisiana have a similar ovarian cycle, except there secondary vitellogenesis does not begin until autumn (Tinkle, 1960). The shorter activity season in Illinois as compared to Louisiana may force more northern snakes to begin secondary vitellogenesis earlier.

In Illinois *O. aestivus,* the right and left ovaries or oviducts had an equal number of secondary vitellogenetic follicles or ova (1-6, X ± 1 SE = 3.5 ± 0.37 for right; 1-7, X ± 1 SE = 3.4 ± 0.41 for left; N = 16). No snake had more than 9 eggs in both oviducts. There was no correlation between number of follicles or ova and snout-vent length in the Illinois sample (r = 0.44; N = 9), but Tinkle (1960) showed a high correlation between follicle number and snout-vent length for Louisiana specimens. Sample size for the Illinois snakes may be too small to reveal a correlation.

Ovulation took place in late May or June (Fig. 2). Oviposition occurred by early July; no gravid females have been collected later that that (Fig. 2) . From 3 to 9 (X = 6.1; N = 9) eggs were laid (data from counts of oviducal eggs and a clutch laid in captivity). Mean greatest axis of oviducal eggs ranged from 17.8 to 28.1 mm. The largest eggs were from a female 413 mm snout-vent length and the smallest from a female 369 mm snout-vent length, but sample size (N = 5) was too small to allow testing of a possible correlation between egg size and snout-vent length.

One female (SIUC R-292) has a single coelomic egg measuring 40 X 10 mm.

A female from Clark County (INHS 10111) deposited 7 eggs from 2147 hr on 25 June 1973 to 0003 hr on 26 June. The tough-shelled, adherent eggs measured 21.5 mm X 9 mm to 28 mm X 11 mm (X = 24.6 mm X 11.1 mm). Movements of embryos were observed by candelling on 25 July. The eggs began hatching 28 July. Six of the snakes had emerged by 30 July. The seventh snake slit the eggshell but died without emerging Total and snout-vent lengths for 5 of the hatchlings were 180-199 mm (X = 189.6 mm) and 115-132 mm (X = 124.2 mm), respectively.

The only other record of reproduction of this species in Illinois is that of 6 eggs found beneath a flat rock (Smith, 1961); no date was given.

Hatchlings have not been collected before 28 July. Although most hatching probably occurs in late July or August, it may occur into September or October, since in other states *O. aestivus* deposits 3-12 eggs from 17 June to 31 August that hatch from 21 July to 13 October (Fitch, 1970).

Information on numbers of eggs, sizes of eggs, and sizes of hatchlings for which localities are cited is shown in Table 2. The few records for Texas snakes (Guidry, 1953; Sabath and Worthington, 1959) suggest that larger complements may be laid there than elsewhere (Table 2). Communal nesting by *O. aestivus* in North Carolina has been reported (Palmer and Braswell, 1976) and may occur in other parts of the species' range.

GROWTH

A scatter diagram of snout-vent lengths against dates of collection for Illinois specimens reveals four size classes; when these are arranged as presumptive age classes, a growth curve is formed (Fig. 3). Although some error may be introduced by individuals growing very rapidly or very slowly, an estimate of growth potential for each age class can be provided by calculating maximum growth (difference between snout-vent length of the largest individual in an age class and the snout-vent length of the largest individual in the next younger age class).

Hatchlings have a maximum growth of 26 mm. Greatest growth is in the first season following hatching (maximum growth = 141 mm). During the second season, growth slows so that the maximum growth is 67 mm. Overlap in size between third year class and older snakes occurs, so that maximum growth for the third season could not be calculated. Rapid growth in the first full season and declining growth thereafter is a common pattern in snakes; e.g., *Carphophis amoenus, Diadophis punctatus, Thamnophis sirtalis, Thamnophis sauritus,* and *Thamnophis butleri* demonstrate such a pattern (Clark, 1970; Fitch, 1975; Carpenter, 1952).

Table 2. Numbers and sizes of eggs, and sizes of hatchlings of *Opheodrys aestivus* from different states.

State	No. Eggs Range ($\bar{X}$)	No. Clutches	Size of Eggs Range ($\bar{X}$) mm	Total Length Hatchlings Range ($\bar{X}$) mm	Source
Ohio	4-7 (5.3)	3	23-31 X 10-11 (27.5 X 10.5)	—	Conant, 1951
Indiana	5-8 (6.3)	3	—	—	Minton, 1972
Illinois	3-9 (6.1)	9	17.3-29.1 X 6.5-12 (23.3 X 9.3)	180-199 (189.6), 5 specimens	present study
Missouri	4-6 (5.0)	2	(26 X 10)	(202)	Anderson, 1965
Oklahoma	3-8 (5.7)	6	(30.6 X 11.0)	—	Carpenter, 1958 Webb, 1970
Texas	8-12 (10.0)	3	23-32 X 10-13 (25.6 X 12.0)	160-205 (183.2)	Guidry, 1953 Sabath & Worthington, 1959
Alabama	2	1	—	—	Mount, 1975
North Carolina	4-8 (5.3)	11	—	175-225 (203.5)	Palmer & Braswell, 1976

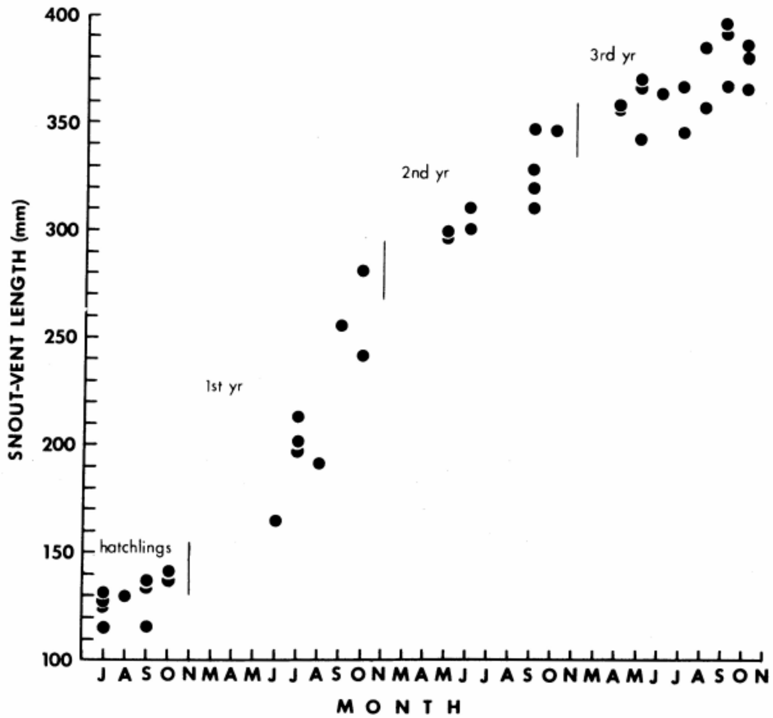

Figure 3. Growth in *Opheodrys aestivus* in Illinois based on length distributions plotted against month of collection.

The smallest mature female from Illinois (SIUC R-828), a post-partum individual, is 347 mm snout-vent length. Size of sexual maturity for females is attained in the late summer or fall of the second season (age of two years) (Fig. 3). Breeding possibly occurs in the third season. Tinkle (1960) found evidence that sexual maturity of Louisiana females is reached in one or two years, at a snout-vent length of approximately 350-400 mm. The extended activity season (and consequent growth period) probably enables the southern snakes to mature at a younger age than Illinois snakes.

ONTOGENETIC VARIATION

Ontogenetic variation in Illinois rough green snakes is expressed in dorsal color, relative head and tail lengths, and relative eye size.

Several authors have commented that hatchling *O. aestivus* are "dull" or "grayish-green" at least until the first skin shedding (Smith, 1950; Anderson, 1965; Minton, 1972; Mount, 1975). Six hatchling *O. aestivus* from Clark Co., Illinois (see Reproduction) were dull gray-green above and whitish below. Smith (1961) noted that preserved juveniles were " more sharply bicolored" than adults. Data on microhabitat preferences

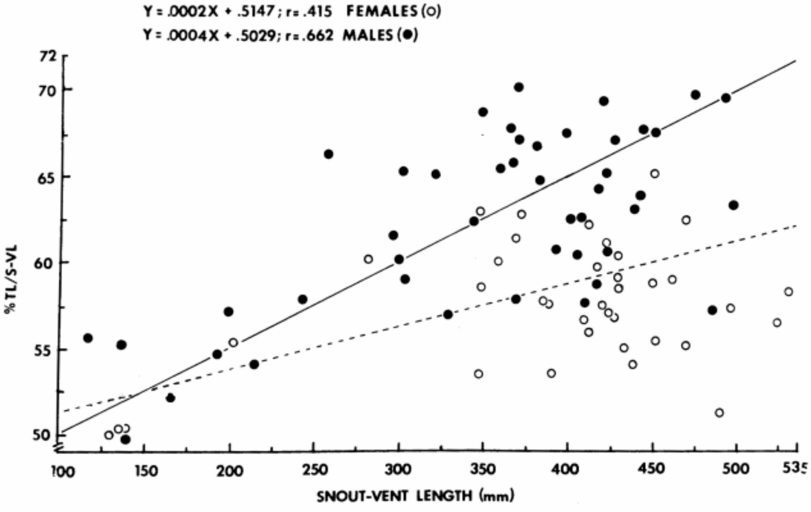

Figure 4. Ontogenetic change in relative tail length (TL), expressed as percentage of snout-vent length (S-VL), in *Opheodrys aestivus* from Illinois.

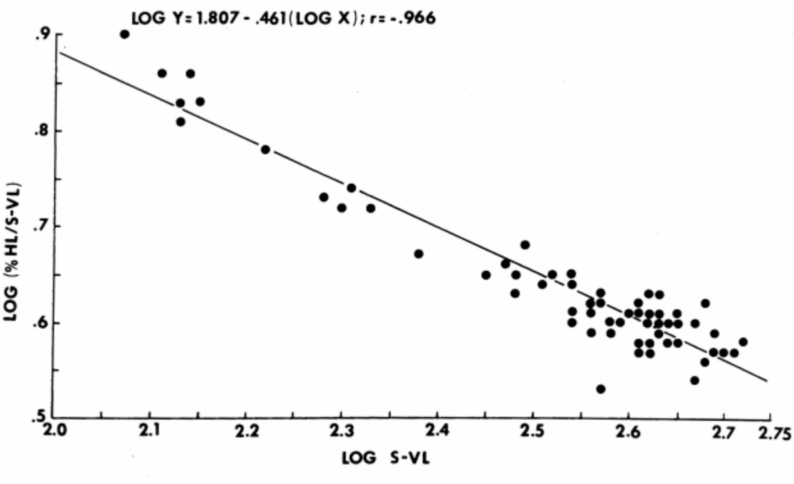

Figure 5. Relationship between relative head length (HL), expressed as percentage of snout-vent length (S-VL), and snout-vent length in *Opheodrys aestivus* from Illinois.

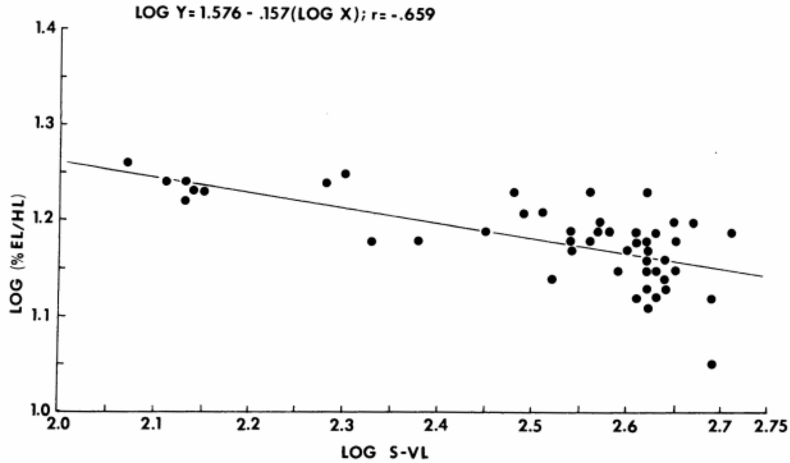

Figure 6. Relationship between relative eye length (EL), expressed as percentage of head length (HL), and snout-vent length in *Opheodrys aestivus* from Illinois.

of baby *0. aestivus* are not available, but the darker ground color may be a cryptic coloration better concealing the young snakes in certain habitats than the bright green adult color.

Tails of juveniles are relatively shorter than those of adults *(Fig.* 4; Smith, 1961). Adult females have shorter tails than males (Fig. 4; Smith, 1961), and the change in proportional tail length is faster in males than in females (Fig. 4). Young *0. aestivus* also have relatively longer heads and larger eyes than do adults (Figs. 5 and 6; Smith, 1961). Large-headedness in young snakes may be an adaptation allowing them to ingest proportionately larger prey items than are eaten by older snakes. This would enable small snakes, faced with the problem of securing appropriately-sized food items, to utilize a larger array of prey sizes. Unfortunately this cannot be tested until data on sizes of prey eaten by different size and age classes of snakes become available.

Palmer and Braswell (1976) noted ontogenetic variation in proportionate tail length of 0. *aestivus* from North Carolina. Hatchlings in North Carolina have longer tails and less range overlap between sexes than those from Illinois (Table 3), possibly reflecting geographic variation in tail length that may occur in adults as well.

Table 3. Variation in tail length/total length of hatchling *Opheodrys aestivus* from Illinois and North Carolina.

State	Males Range (Mean), N	Females Range (Mean), N
Illinois	0.332-0.357 (0.348), 3	0.333-0.355 (0.340), 4
North Carolina (data from Palmer and Braswell, 1976)	0.357-0.388 (0.371), 22	0.331-0.378 (0.359), 20

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APPENDIX 1

Specimens examined during this study are as follows: Alexander Co.: INHS 5340; Bond Co.: INHS 8251-8252; Calhoun Co.: INHS 7263; Clark Co.: INHS 8863, 10109-10112, 10266; Coles Co.: INHS 1281, 1606, 1621, 1858-1859, 2125, 4974, 8997; Cumberland Co.: INHS 1943; Effingham Co.: INHS 1282, 4181, 4372; Gallatin Co.: INHS 1408; Hamilton Co.: INHS 5339; Hardin Co.: INHS 8247; Jackson Co.: INHS 1800-1802, 2539, 3288, SIUC R-69, R-71, R-93, R-100, R-104, R-105, R-140, R-141, R-187, R-230, R-296, R-298, R-318, R-351, R-520, R-622, R-678, R-823, R-1359, R-1759, R-1761; Jasper Co.: INHS 2047; Jefferson Co.: INHS 8275, 9284, SIUC R-292; Johnson Co: INHS 2523-2524, 4373; Madison Co.: INHS 1283; Marion Co.: INHS 8998, 9784; Monroe Co.: INHS 3672, 4322, 4414; Perry Co.: INHS 9878; Pike Co.: INHS 5828, 7745; Pope Co: INHS 1365-1368, 1581, 2215, SIUC R-914, R-925; Randolph Co.: INHS 3712, 4031, 4321, 4413; Richland Co.: INHS 5219; Union Co.: INHS 1284-1286, 1582, 3350, SIUC R-132, R-172, R-335, R-681, R-828, R-1358; Wabash Co.: INHS 1280; White Co.: INHS 7208, 7846; Williamson Co.: INHS 6798, SIUC R-131, R-133, R-807.